Connecting the Earth to the Sun:
Students Monitor Solar Disturbances to Earth‘s Ionosphere

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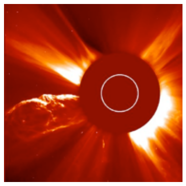
An education project to build and distribute inexpensive ionospheric monitors to students around the world. Two versions of the monitor exist – one low-cost and one research quality.

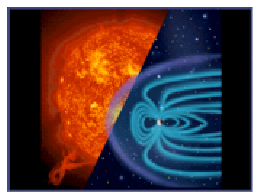


Earth's ionosphere reacts strongly to the intense x-ray and ultraviolet radiation released by the Sun during a solar event. By using a receiver to monitor the signal strength from distant VLF transmitters, and noting unusual changes as the waves bounce off the ionosphere, students around the world can directly monitor and track these Sudden Ionospheric Disturbances (SIDs).

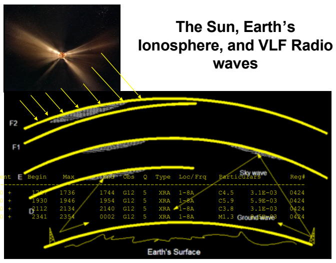
Stanford's Solar Center, in conjunction with the Electrical Engineering Department's Very Low Frequency group and local educators, have developed inexpensive SID monitors that students can install and use at their local high schools. Students "buy in" to the project by building their own antenna, a simple structure costing less than $10 and taking a couple hours to assemble. Data collection and analysis is handled by a local PC, which need not be fast or elaborate. Stanford will be providing a centralized data repository and chat site where students can exchange and discuss data.

Because there are VLF transmitters scattered around the world, the monitors can be placed virtually anywhere there is access to power.

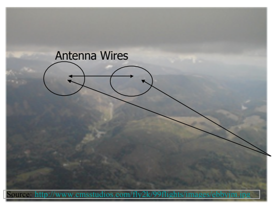
Stanford Solar Observatories Group



The Sun, Earth's Ionosphere, and VLF Radio waves

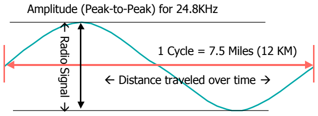


One of ~24 VLF broadcasting stations around the world --, Jim Creek, WA "NLK" 24.8KHz



200' Towers

Amplitude (Peak-to-Peak) for 24.8KHz

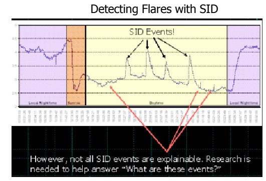


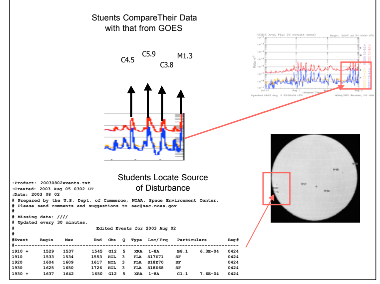
Interpreting SID Data

The students receive their SID data as a signal strength value and a timestamp. The data are easily read by Excel and graphed. There is a characteristic sunrise and sunset shape to the graph, which can be used to test the monitor. Solar events show up as spikes in the signal strength. Students compare their spikes to data from the GOES satellite to identify flares. Occasionally, students will detect flares that the (human) GOES data interpreter have missed! Students can also track down the solar active region which generated the disturbance.

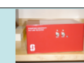
Students also pick up other signals, which could be from Gamma Ray Repeaters, lightning storms, or even local interference. By talking with each other and checking other data, they attempt to determine what caused their unidentified signals.

Detecting Flares with SID





For more information, see **solar-center.stanford.edu/SID**

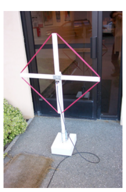


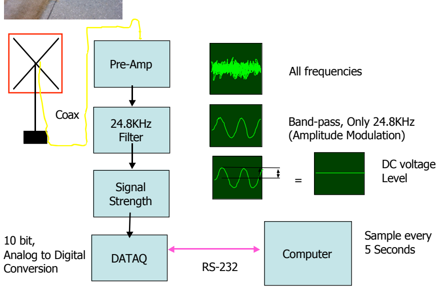
SID – The low-cost monitor

Sudden
Ionospheric
Disturbance
monitor

SID box before silkscreening

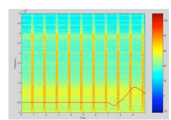
- Preassembled and pretuned
- Students build their own, simple antennas
- Data handled and plotted by Excel
- Changeable frequency boards tuned to particular VLF transmitters around the world
- Easy to set up and use
- Suitable for use in high school and community colleges
- Low cost (~$100 per monitor)



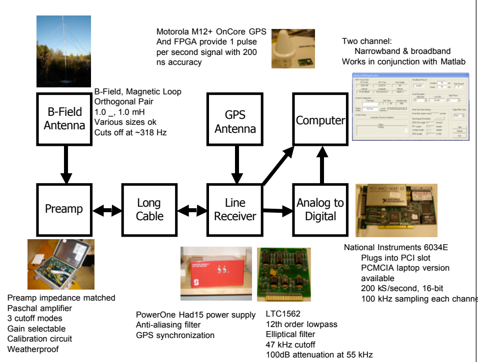


AWESOME -- The Research Quality Monitor

Atmospheric
Weather
Educational
System for
Observation and
Modeling of
Effects



- Designed to capture ELF/VLF frequencies, roughly 30 Hz-50kHz
- Dual use system --
  - Daytime: monitor solar activity
  - Nighttime: monitor atmospheric phenomena, e.g. lightning
- Precision timing/phase accuracy
- So sensitive that nearly any signal above the ambient Earth noise floor can be detected
- Broadband
- Easy to build, set up, use, and repair
- Data appropriate for high school as well as solar and ionospheric researchers
- Low cost (~$1700 per monitor)



List of Partners

Stanford Solar Center
- Deborah Scherrer
- Hao Thai
- Sharad Khana
- Scott Winegarden
- Paul Mortfield

Stanford Solar Observatories Group
- Philip Scherrer
- Sarah Gregory

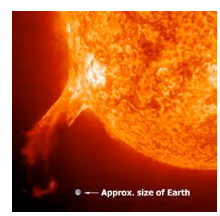
Stanford EE Department
- Umran Inan
- Morris Cohen
- Justin Tan

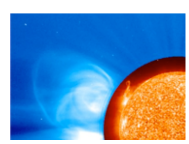
Cal State University Hayward
- Ray Mitchell, Chief Engineer

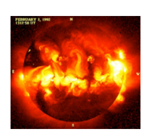
Chabot Community College
- Shannon Lee
- Tim Dave

San Lorenzo High School
- William Clark
- Richard Styner

Castro Valley High School
- Sean Fotrell
- Kenny Oslund (now at CalTech)







VERY LOW FREQUENCY (VLF) Radio Transmission Stations

Note – VLF signals can be received all over the world, whether there is a station nearby or not!

Station Site	*Station ID*	*Frequency (kHz)*	*Radiated Power (kW)*
U.S. Navy			
Cutler, ME	NAA	24.0	1000
Jim Creek, WA	NLK	24.8	250
Lualualei, HI	NPM	21.4	566
LaMoure, ND	NML	25.2	500
Aquada, Puerto Rico	NAU	40.8	100
Keflavik, Iceland	NRK	37.5	100
Australia			
Harold E. Holt	NWC	19.8	1000
Federal Republic of Germany			
Rhauderfehn	-	18.5	500
Burlage	DHO	23.4	-
France			
Rosnay	HWU	15.1	400
St. Assie	FTA	16.8	23
LeBlanc	HWU	18.3	-
Iceland			
Keflavic	TFK	37.5	-
Italy			
Tavolara	ICV	20.27	43
Norway			
Noviken	JXN	16.4	45
Russia			
Arkhanghelsk	UGE	19.7	150 input
Batumi	UVA	14.6	100 input
Kaliningrad	UGKZ	30.3	100 input
Matotchkinchar	UFQE	18.1	100 input
Vladivostok	UIK	15.0	100 input
Turkey			
Bafa	TBB	26.7	
United Kingdom			
Anthorn	GQD	19.0	500
Rugby	GBR	16.0	45
London	GYA	21.37	120

All information courtesy of Bill Hopkins, Technical Representative for Pacific-Sierra Research Corp.